TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 379

DIGEST OF SOME OF THE SPEECHES MADE AT THE

FIFTEENTH REGULAR MEETING OF THE

"WISSENSCHAFTLICHE GESELLSCHAFT FÜR LUFTFAHRT"

June 17, 1926, in Düsseldorf, Germany

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One of the principal addresses was made in the forenoon by Dr. Rohrbach, who spoke on the "Design and Problems of Light Construction." His lecture dealt mainly with questions of material and manufacturing, in so far as the small experience thus far gained in production allows general principles to be worked out.

The most important problem for the airplane designer is to find the best solution as regards utilization and production.

As far as adaptation to light construction is concerned, rather uniform solutions have already been reached, while it is more difficult to decide upon the questions of manufacturing, since the latter depend upon technical, political and financial conditions.

Today the choice between wood and metal is generally favorable to the latter, owing to its durability and notwithstanding its higher cost. In choosing the metal to be used, duralumin is found to have the following advantages over steel: simpler

* From "Zeitschrift für Flugtechnik und Motorluftschiffahrt," July 14, 1926, pp. 277-286.

and stronger assembling, more advantageous characteristics of strength, simpler shapes and shorter periods required for working. Open sections are better for light construction than hollow ones, since they are more easily riveted together and the connections weigh less. They are moreover easily inspected and therefore better protected against corrosion, which is of particular importance for seaplanes. Metal covering is better than fabric covering, which must be often renewed and thus grows more expensive in operation, notwithstanding its low original cost. For folding wings, metal covering has also the advantage of easy inspection, which simplifies the repair work.

Large airplanes are best built out of smooth duralumin sheets and strips, which are the simplest forms of this material. It is best to use open sections, which are similar to designs used in shipbuilding and have supporting covering. The wing and tail planes are thus formed out of parts which are easily riveted together.

Cheap production is possible only when all the work is carefully planned. The first condition is a well developed drafting department, which works out even the smallest details. Special departments of the drafting office design the model and make the aerodynamic and strength tests. After the complete drawings and details of the first airplane of a new type are worked out, a series of twenty similar ones can be easily built. All separate parts are carefully tested by the inspection serv-

ice, in order to detect possible defects before assembling.

The work is reduced by using simple apparatus, which is not expensive, owing to the simple shapes of the material used. The cheapness of the apparatus is important for the development of new types and for quantity production. In the Rohrbach factory a reduction of 30-50% in the working time has been effected by the introduction of piece work. A constant control of the working time and expenses may be exerted through a practical system of calculation, which leads to simplification and price reduction. This close cooperation of the drafting office, workshop and inspection department greatly affects the cost of production.

At the close of the business session, in the afternoon, there were several short speeches, the first and principal address being made by Engineer Hans Herrmann on "Seaplane Hulls and Floats."

Engineer Herrmann called attention to the fact that seaplanes have been built for 12 to 14 years and that much knowledge has been acquired on this subject, the present lecture being the first systematic digest of the important technical data on seaplanes.

The introduction gives a general view of the development of aviation in various countries, suggesting that the further development of aviation in Germany be concentrated in one firm hand.

The water resistance is always characterized in the same way. Its maximum value lies around 40% (very seldom 50%) of the

take-off speed. The water resistance is subject to slight changes, owing to variations in the load, take-off speed and hull shape. The best study of the water resistance was made by Madelung. The resistance is expressed as a fraction of the load supported by the water and put down in a table for various taxying and take-off speeds of the seaplane.

The determination of the water resistance is made by tests in shipbuilding laboratories. In Germany they are made in the Hamburg shipbuilding water tank (the largest in the world). The calculation is based on Froude's Law, taking the friction into consideration.

Take-off and alighting are clearly outlined and a simple graphic way for the determination of the time and distance required for the take-off is indicated, which corresponds to the determination of the arriving time of trains.

Experience shows that hulls without a step are useless; that the step must be located near the center of gravity; that a V-shaped bottom increases the resistance, but reduces the landing shock; that high landing speed is not advisable; that too bluff a bow only causes unnecessary spray and that the starting time remains practically the same for calm weather as for wind and rough sea. A great number of experiments on water resistance supply interesting material, which is of practical value to the designer.

Twin-float seaplanes, up to a total weight of 2 or 3 tons,

are superior to flying boats when seaworthiness is desired. For the larger types, and especially when the load is not concentrated near the center, flying boats are better. There is no fundamental superiority of certain flying boats or twin-float seaplanes. All depends on careful observation of even the smallest details.

Metal hulls are much superior to wood hulls, because they do not absorb water. They are more expensive, however.

Dr. B. Spieweck, of the German Laboratory for Aeronautical Tests, Berlin-Adlershof, spoke on the "Photogrammetric Starting and Landing Measurements."

The leacture deals with a new method for the determination of the flight path of an airplane, particularly for starting and landing. A front or rear photograph of the airplane is taken directly in the flight-path plane, during straight flight. The span, in the photograph, is measured by means of a "comparator." From the known real span and the measured one, as well as from the focal length of the camera used, the distance between the airplane and the camera can be calculated. The altitude is given by the distance between airplane and horizon, measured on the photograph. The German Laboratory for Aeronautical Tests has made a great number of such measurements during the last six months. As a result of the practical experience thus gained, a special motion-picture camera has been

built which enables 150 successive exposures at intervals up to one second. In order to make an accurate record of time, a stop watch is also photographed. This camera was used for the first time in the South-German contest at Mannheim early in June, 1926.

Dr. F. Seewald, of the German Laboratory for Aeronautical Tests, spoke on "Theoretical and Experimental Determination of Propeller Deformations."

Propellers in operation are subject to extremely high working stresses. However, it has been hitherto impossible to determine these stresses with satisfactory accuracy. The difficulty of this problem is due to the fact that the shape of the blade greatly affects the stresses, particularly the bending moments. We may, for instance, consider the blade to be divided by cross sections into a certain number of parts. The centrifugal force (at the center of gravity) and the air reaction then act on each part. Now, if the centers of gravity of these parts are not on the same line in a radial direction, the centrifugal forces create moments which tend to bend the blade into this line. It is of no importance whether the curvature or inclination of the blade axis was already existent or resulted from the elastic deflection due to the load. Since the centrifugal force is far more important than the other forces, very slight deviations of the blade axis from the radial line produce moments, which have to be taken into consideration.

At the same time the original shape of the blade, as well as its deformation due to load, must be taken into consideration in working out the conditions of equilibrium. The first part of the problem, namely, the calculation of static stresses for the original shape of the blades is easily solved. Changes in these static pressures, due to elastic deflections, can only be calculated when these deflections, which themselves depend on the static pressures, are known. This part of the problem was solved in a way similar to the investigation of Reissner on "The Strength of the Propeller," Technische Berichte II, 1917, page 315. There, however, the propeller blade is treated as a straight untwisted bar.

It is assumed that the yet unknown elastic deflection may be expressed with sufficient accuracy by an exponential series as, for instance, the deflection in the direction of flight by the following equation

$$\eta = a_0 + a_1 r + a_2 r^2 + a_3 r^3 + \ldots .$$

corresponding to the deflection perpendicular to it and to the elastic torsion. With the help of these expressions, all the requisite quantities can be determined as, for instance, the bending moments in terms of the yet unknown constants. Supposing that the bending moments, thus calculated, are correct, the calculation of the corresponding deflection will present no difficulty and this deflection must then be identical with the

assumed one, as expressed by the above-mentioned series. This condition supplies the equations required for the determination of the constants. As soon as these are known, the final formula is obtained, and all the static pressures can be determined.

A propeller of a peculiarly curved shape was thus tested. A short time ago several accidents were caused by propellers of the same design, which broke in flight. Investigation showed that the centrifugal forces created considerably greater bending moments than the air resistance, and that the fault was due to the curved shape of the propeller, which had probably been chosen in order to utilize to the utmost the compensating effect of the centrifugal force. This proves that one must be very careful in applying the compensation of the centrifugal force. The elastic deflection of an originally straight blade always produces a compensation.

In order to obtain an experimental confirmation of this calculation, the deflection of the above-mentioned propeller was measured. The entire outline of the blade was covered with small tin-foil plates interrupted at 3-centimeter intervals, thus forming a ladder of spark gaps. An electric current was then sent through them and the sparks were photographed twice, the propeller being first at rest and then in motion. The deflections could thus be determined with great accuracy for any desired part of the blade. They satisfactorily confirmed the results of the calculation.

Professor Von Karman spoke on "Experimental Problems of Modern Aircraft Statics."

Aircraft statics are generally based on the principles of framework statics. It is attempted to divide the wing and the fuselage structure into parts of a framework and to determine the distribution of forces according to the principles of the statics of assembled framework. This process gave comparatively good results when applied to multiplanes, braced monoplanes and fabric-covered fuselages, but could not be applied to the calculation of cantilever monoplanes and plywood-covered fuselages. The new problems, which thus arise in aircraft statics, particularly the strength calculation for bending and torsion of a rigid wing and the effect of a plywood covering on a lifting surface, can only be solved by methods derived from the theory of elasticity. The main difficulty resides in the fact that the usual methods in technical science for calculating the strength of materials can not be directly applied to the shapes designed for aviation, as they are generally assembled out of very thin parts, which have very little inherent stiffness. The problems are, however, too difficult to be solved by theoretical methods only, although some very valuable contributions were made by Thalau, Reissner and Biezeno. The lecturer spoke of the experimental program and the methods adopted for carrying it out at the Aerodynamic Institute of the Technical High School of Aachen, with the financial support of the Transport Department

of State and of the Relief Association of German Scientists. The aim of this Institute is to supply useful data for practical calculation by means of systematic fundamental tests, as well as by full-scale wing and fuselage tests. Many of the problems considered are of importance not only for aviation, but also for the manufacture of vehicles in general, for shipbuilding, etc.

Engineer Scheubel spoke on "Tail Flutter and How to Avoid It."

During recent years, vibrations of the rudders and elevators of airplanes have been frequently noticed, but no satisfactory explanation could be found. On the other hand, similar vibrations of the wings have been studied, which make it possible to calculate the possibilities of vibration of the tail planes, particularly of the elevator. There are two different forms of vibration. The first, a pitching vibration of the entire airplane accompanied by an oscillation of the elevator, is generally harmless. The second, a bending and torsional vibration of the fuselage and the stabilizer, with an up-and-down oscillation of the elevator ("tail flutter"), has caused accidents. The characteristic features and the conditions of stability for this flutter have been determined on a model and the idea of the "critical velocity" (i.e., of the speed at which this flutter can begin) has been introduced. Moreover, the corresponding vibrations of the stabilizer and elevator for various disturbance frequencies and various speeds have been stud-

ied on the same model.

Some practical means to avoid this tail flutter were given at the end. The best way consists in attaching counterweights to each half of the elevator. Other means, which are generally sufficient, consist in giving a high torsional and bending stiffness to the fuselage and in not balancing the elevator.

Dr. Weidinger and Engineer Schrenk spoke on "Determination of the Wing-Section Drag of an Airplane in Flight," Weidinger dealing with "The Apparatus and the First Tests," while Schrenk outlined "Further Results of the Tests."

The article by Betz in "Zeitschrift für Flugtechnik und Motorluftschiffahrt," of February 14, 1925, pp. 42-44, describes a new method for the direct determination of the wing-section drag (See N.A.C.A. Technical Memorandum No. 337: "A Method for the Direct Determination of Wing-Section Drag"). Instead of the forces, the pressures before and behind the wing are measured. From the differences in pressure, the lost energy of the flow and the corresponding drag of the given wing section are then determined. This method renders the measurements independent of the size of the model. They even grow more accurate and easy with increasing dimensions of the wing section to be tested. This fact favors the application of this method to airplanes in flight.

At the request of Professor Prandtl, Weidinger designed, in the autumn of 1925, at the Deutschen Versuchsanstalt für Luftfahrt, a testing apparatus, which was well suited for this kind of work. He also made various tests on a Junkers airplane, type A.20.

Schrenk continued these tests. The apparatus was improved, the method for working out the test results was simplified, and some important results were obtained with corrugated sheet-metal wings and with both smooth and rough plywood wings.

This method makes it possible to find a correct reply to the question as to what should be the thickness and cross-sectional shape of a cantilever wing at its root. Hitherto, it has been impossible to give a satisfactory answer to this question, due to the low index values of the wind-tunnel tests. This is only one of the important applications of this method.

Translation by Paris Office,
National Advisory Committee
for Aeronautics.

Appendix

At the same meeting of the W. G. L., Dr. E. Rumpler spoke on "The Problem of the Trans-Ocean Airplane."

Dr. Rumpler first showed that the flight from Europe to North America is much more difficult than to South America since, due to the lack of suitable landing places in the North Atlantic, the longest non-stop stage is 3900 km (2424 miles), as against 2850 km (1771 miles) in the South Atlantic.

He then spoke of the difficulties encountered in the construction of large airplanes, which are largely due to the fact that the useful load grows relatively smaller, as the size of the airplane is increased. He expressed the opinion that new ways must be found.

On the basis of the new principle developed by Dr. Rumpler, it will yet be possible to build large airplanes capable of carrying several hundred persons.

While airplanes thus far made are loaded centrally or nearly so, thereby causing the weight relations to become more unfavorable with increasing size, due to the bending stresses on the wings, Dr. Rumpler expresses the opinion that the dangerous increase in these bending stresses can be avoided by decentralizing the load. Each portion of the useful load would then be supported by the nearest part of the wing. On this principle it would be possible to increase the size of an air-